

APPLICATION  
OF  
ORGANIC ACIDS  
TO THE  
EXAMINATION OF MINERALS.  
THIRD PAPER.

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APPLICATION OF ORGANIC ACIDS TO THE EXAMINATION OF MINERALS. *Third Paper.* By H. CARRINGTON BOLTON, of Hartford, Conn.

37. In the two papers previously published under the same title<sup>1</sup> we have shown that citric acid has a power of decomposing minerals little less than that possessed by hydrochloric acid, and that the organic acid can be advantageously employed in field-work for assistance in determining species. In the second of these papers we stated that the results obtained by the *prolonged* action of citric acid on minerals differed greatly from those recorded in the accompanying tables, and gave notice of our intention to return to the subject at a subsequent period. We have continued our researches and gained a few additional facts which we deem of sufficient interest to warrant a third or supplementary paper on the subject.

The results given in the tables (here reproduced for convenience) were obtained by acting on the minerals in fine powder: first, in the cold for a few hours, and secondly, at a boiling heat for a few minutes. We find, however, that many species which resist the brief action of a boiling concentrated solution of citric acid are more or less completely decomposed by prolonged contact with the same solution at the ordinary temperature of the work-room, say 60° to 70° Fahr. But a small number of the two hundred minerals embraced in the tables were submitted to the prolonged action of the acid solution, and those tested were selected as representative of groups, sulphides, oxides, silicates, etc. The progress of decomposition was noted at various periods from a few days to more than two years. A solution of citric acid concentrated in the cold was used in all the experiments.

38. *Sulphides.* Chalcocite showed signs of decomposition at the end of ten days, and at the expiration of several months yielded a partial solution of a pure green color.

Ullmannite showed signs of decomposing in two days, and afforded in a month a very dark colored solution.

Arsenopyrite was attacked in a few days. Pyrite showed decided evidence of decomposition in eight days; one month later the solution acquired a reddish yellow color and reacted for iron and sulphuric acid.

<sup>1</sup> Annals N. Y. Acad. Sciences. Vol. I, p. 1, 1877, and Vol. II, p. 1, 1880.

Chalcopyrite acts similarly, the solution being of a greenish yellow hue and reacting for copper and sulphuric acid. One gramme of the mineral lost about eleven per cent of its weight after fourteen months' contact with the acid solution. In general quantitative experiments were not conducted, for it soon became clear that the amount of decomposition was proportionate to the time and would require more attention than the results to be gained warranted.

Smaltite was decidedly attacked after eight days — the presence of sulphuric acid in the colored solution was noted. Tetrahedrite was strongly attacked in about four months. Cinnabar, orpiment, argentite and pyrargyrite resisted the acid solution altogether.

39. *Oxides*. The experiments recorded in this brief supplement were made with only those minerals which resisted the acid solution on boiling, and since it was obviously useless to test such bodies as quartz, corundum, rutile, etc., only the three oxides of iron remained of this class for examination.

Magnetite and limonite were strongly attacked in eight days; hematite yielded much more slowly, showing decided decomposition after several months.

Exposure to sunlight, as might be expected, diminished the intensity of the colored iron solutions.

40. *Silicates*. Of the silicates examined datolite is by far the most quickly decomposed by the acid solution; after twenty-four hours it yields gelatinous silica. Datolite should probably be transferred from column H of the tables to column D.

Hornblende, pyroxene, almandite, epidote, vesuvianite and serpentine were decidedly decomposed in eight days; after one month hornblende, almandite and epidote yielded colored solutions and slimy silica, and serpentine gave gelatinous silica. After fourteen months contact with the acid solution (occasionally agitated) the hornblende and pyroxene were very completely decomposed, the solutions having a dark brown color and full of floating silica. Actinolite seems to be less easily decomposed than common black hornblende. The serpentine after fourteen months yielded a dry gelatinous mass.

The feldspars are very unequally attacked under similar conditions. Labradorite yields the easiest, decomposition being noticed after eight days and slimy silica forming in the course of some months. Orthoclase and oligoclase showed marked signs of decomposition after eight months, but albite is doubtful. Tourmaline

and staurolite yielded to the acid after four or five months, the latter forming a solution colored by iron and slimy silica. Talc and kyanite appear to resist the action of citric acid.

Muscovite and biotite yield very slowly, the latter showing signs of decomposition the sooner. After two years' subjection to the acid solution very minute scales of mica separate, and some slimy silica appears in the slightly colored liquid.

41. We have detailed these simple observations somewhat minutely because we believe they have an important bearing on geological disintegration and erosion. At the Saratoga meeting of the A. A. A. S., my friend Dr. Alexis A. Julien presented an exhaustive summary and analysis of all known observations, concerning the geological action of the humus acids<sup>2</sup>; in this paper he notes the negative character of the results I had obtained with a number of minerals, *e. g.*, pyrite, augite, hornblende, the feldspars, micas, etc., and says: "but the nature and strength of the solvent employed, and the brief duration of each trial seem at present insufficient to justify generalizations, notwithstanding the suggestiveness of certain results." My subsequent observations have confirmed his views. Generalization is still of doubtful value, yet we are tempted to make the venture. In the following table we have arranged the chief rock-forming minerals, with a

T A B L E  
SHOWING APPROXIMATE RELATIVE DISINTEGRATION OF ROCK-FORMING  
(AND ASSOCIATED) MINERALS BY CITRIC ACID IN SOLUTION.

<i>Quickly decomposed.</i>	<i>Slowly decomposed.</i>	<i>Very slowly decomposed.</i>	<i>Not decomposed.</i>
Carbonates, Phosphates, Prochlorite, Chrysolite, Nephelite.	Serpentine, Pyroxene, Hornblende, Labradorite, Garnet, Epidote, Vesuvianite, Pyrite, Limonite, Magnetite, Gypsum (?).	Orthoclase, Oligoclase, Albite (?), Biotite, Muscovite, Tourmaline, Staurolite, Hematite.	Quartz, Corundum, Spinel, Beryl, Fluorite, Barite, Talc (?), Kyanite (?).

few of their associates, under four heads indicating their relative disintegration by citric acid; the position of each mineral is of course only approximate, and it is not intended to indicate that all the species in one column are equal in degree of their decomposition. The application of this table to the consideration of

<sup>2</sup> Proceedings Am. Assoc. Adv. Sci., Saratoga Meeting, Vol. 28, p. 311, 1879.

geological phenomena is a subject which I do not venture to discuss ; if we have a right to assume that the disintegrating effect of the acids of humus differs from that of the other organic acids in degree rather than in kind, the Table may prove a small contribution to chemical geology.

## TABLES

SHOWING THE BEHAVIOR OF CERTAIN MINERALS WITH CITRIC ACID, ALONE AND WITH REAGENTS.

I.			
DECOMPOSED (IN FINE POWDER) BY A SATURATED SOLUTION OF CITRIC ACID.			
1. IN THE COLD.			
A. <i>Without evolution of gas.</i>	B. <i>With liberation of CO<sub>2</sub>.</i>	C. <i>With liberation of H<sub>2</sub>S.</i>	D. <i>With separation of Si O<sub>2</sub>.</i>
Clausthalite, Leucopyrite, Atacamite, Brucite, Gummite, Pyromorphite,* Mimetite, Triphylite, Triplite, Vivianite,! Libethenite,! Olivinite,! Pseudomalachite, Wavellite, Pharmacosiderite,! Torbernite, Autunite, Ulexite,! Cryptomorphite,! Anglesite, Brochantite.!	Calcite,! Dolomite,* Gurhofite,! Ankerite,* Rhodochrosite,* Smithsonite,* Aragonite,! Witherite,! Strontianite,! Barytocalcite,! Cernssite,! Malachite,! Azurite.*	Stibnite, Galenite, Alabandite,! Sphalerite, Pyrrhotite.	Wollastonite, Rhodonite,! Chrysolite, Willemite,! † Nephelite, Lapis lazuli, Chondrodite, Pectolite,! † Chrysocolla,! † Laumontite,! † Apophyllite, Calamine. † † Thomsonite,! Natrolite,! † Mesolite,! Analcite, Chabazite, Herschelite, † Stilbite, Deweylite, Prochlorite.
2. ON BOILING.			
E. <i>Without evolution of gas.</i>	F. <i>With liberation of CO<sub>2</sub>.</i>	G. <i>With liberation of H<sub>2</sub>S.</i>	H. <i>With separation of Si O<sub>2</sub>.</i>
Cuprite,! Zincite, Melanconite, Goethite,* Limonite,* Allanite, (?) Apatite,* Wolframite,* Wulfenite, Crocoite, Gypsum.*	Hausmannite, † Pyrolusite, † Manganite, † Psilomelane, † Wad. † Magnesite,! Siderite.!	Bornite, Jamesonite,* Bourbonite,* Boulangerite, Kermesite.	Tephroite, † Ilvaite, Phlogopite,* Datolite, † † Prehnite,* Heulandite, Serpentine, Chrysotile, Retinalite, Bastite, Genthite, Gieseckite,* Jefferisite, Masonite.*
<i>and those in A.</i>	<i>and those in B.</i>	<i>and those in C.</i>	<i>and those in D.</i>



## II.

## DECOMPOSED BY A BOILING SOLUTION OF CITRIC ACID MIXED

I. WITH SODIUM NITRATE.		K. WITH POTASSIUM IODIDE.	
Silver,	Cobaltite, †	Realgar,*	Olivine,
Mercury,	Ullmannite, †	Orpiment,*	Almandite,
Copper,	Marcasite, †	Cinnabar, †	Pyrope,
Arsenic,	Arsenopyrite, †	Hematite,*	Colophonite,
Antimony,	Nagyagite,	Menaccanite,*	Epidote.
Bismuth,	Covellite, †	Washingtonite,*	
Sulphur,*	Berthierite, †	Magnetite,*	<i>and most of</i>
Bismuthinite,	Pyrargyrite,	Franklinite,	<i>those in</i>
Domeykite, †	Tetrahedrite, †	Braunite,	<i>A, B, C, D, E, F,</i>
Argentite,	Tennantite, †	Enstatite,	<i>G, H, and I.</i>
Hessite,	Stephanite,	Hypersthene,	
Chalcocite, †	Polybasite, †	Augite,	
Tiemannite, †	Enargite, †	Spodumene,*	
Millerite, †	Uraninite, †	Hornblende,*	
Niccolite, †	Hübnerite.	Actinolite,*	
Pyrite, †		Pargasite,*	
Chalcopyrite, †	<i>and those in</i>		
Linnaeite,	<i>C and G.</i>		
Smaltite, †			

## III.

## L. MINERALS NOT DECOMPOSED BY THE ABOVE REAGENTS.

Graphite.	Iolite,	Talc,	Labradorite,
Molybdenite,	Biotite,	Kaolin,	Oligoclase,
Proustite,	Muscovite,	Épidolite,	Albite,
Fluorite,	Lepidolite,	Columbite,	Orthoclase,
Cryolite,	Wernerite,	Samarskite,	Tourmaline,
Corundum,	Leucite,	Spinel,	Scheelite,
Diopside,	Andalusite,	Chromite,	Barite,
Petalite,	Fibrolite,	Chrysoberyl,	Celestite,
Asbestos,	Kyanite,	Cassiterite,	Anhydrite.
Beryl,	Topaz,	Rutile,	
Zircon,	Titanite,	Quartz,	(Two hundred
Vesuvianite,	Staurolite,	Hyalite,	species.)
Zoisite,	Bowenite,	Anorthite,	

N. B.—The gases evolved are examined with acetate of lead test paper, the solutions with appropriate reagents.


The kind and degree of action are indicated in the above Tables by the following signs:—

† Completely decomposed or dissolved.

\* Feebly attacked.

† The CO<sub>2</sub> evolved is derived from the Citric Acid.

‡ Gelatinizes.



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